

**AC 2010-829: SUCCESS IN FALL MATH COURSE FOR FRESHMAN STUDENTS
ACCEPTING**

Nancy O'Connor, Villanova University

Gerard Jones, Villanova University

Success in Fall Math Course for Freshman Students Accepting AP Tests/Villanova Equivalents for Introductory Math Courses – A Three-Year Study

Abstract

In the College of Engineering at Villanova University, incoming freshman students are offered Villanova course credit for introductory calculus courses based on their achieved AP test scores. Incoming students as well as their parents often look to the faculty and/or administrative staff for practical advice in making a decision about AP options. Results of a three-year study, presented in the paper, show the relationship between AP test scores and student success after accepting offered calculus credit and moving on to another course, compared to declining calculus credit. By making these data available, along with their understanding of their own capabilities, students may make a better judgment on whether or not to use their AP credit for calculus courses.

The study considered course performance data over a three-year period. The table and figures presented in the paper demonstrate relative first-math-course success for incoming students who elected to accept or not to accept the offered credit.

While this three-year sampling is small, it could be used to offer practical advice to incoming students and their parents who are trying to make a decision about accepting all, part, or none of the offered AP calculus credit.

Background

1.0 General

There have been a number of studies intended to determine whether or not success on AP Math exams translates into adequate preparation for the study of calculus in college. One study was done by researchers at Texas Christian University and Mississippi State University to investigate whether taking AP courses in high school had an effect on students' first year of college success. The study concluded that "AP experience may serve as a signal of high ability and motivation, but it does not by itself indicate superior academic readiness."¹ Harvard University and University of Virginia researchers, after examining the question of whether students who had taken AP courses in high school performed as well in college as AP advocates said they should, concluded that "doing well in an Advanced Placement science course in high school does not guarantee that a student will do equally well in an introductory college-level course in the same subject."²

A study at Notre Dame University examined the question of how students with AP credit for calculus compared with students who arrived at the university without having had the AP calculus experience. "In Calculus III, those students who arrived with AP credit for the first two calculus courses outperformed those students who took Calculus I and II courses at the university."³ Another investigation examined the question of whether it makes sense for students who have done well in AP Calculus to skip Calculus I in college. The study concluded that "while the evidence suggests that there is little or no benefit in retaking a calculus course for

which the student is entitled to AP credit, there is some indication that some students are better served by being allowed not to place as far as they are entitled.”⁴

A study at Purdue University, Department of Freshman Engineering, states that “there is a correlation between success in the engineering area and a complete understanding of the basic mathematics principles.”⁵

2.0 AP Calculus AB/BC Topic Outline

There are two AP Calculus tests: test 66 Calculus AB and test 68 Calculus BC. Calculus BC is the more challenging test and includes topics not covered in Calculus AB. A Calculus AB subscore, called test 69, is reported based on performance on the portion of the Calculus BC exam devoted to Calculus AB topics. For the purpose of offering credit, test 69 scores are treated as test 66 scores.

The following information is extracted from the College Board Calculus AB/Calculus BC Course Description booklet, May 2006, May 2007. This publication follows most closely the course descriptions used during this study’s data collection.

Topic Outline for AP Calculus (topics in **bold** apply only to Calculus BC.)⁶

1. Functions, Graphs, and Limits
 - a) Analysis of graphs
 - b) Limits of functions (including one-sided limits)
 - c) Asymptotic and unbounded behavior
 - d) Continuity as a property of functions
 - e) **Parametric, polar, and vector functions.**
2. Derivatives
 - a) Concept of the derivative
 - b) Derivative at a point
 - c) Derivative as a function
 - d) Second Derivatives
 - e) Applications of derivatives
 - Analysis of planar curves given in parametric form, polar form, and vector form, including velocity and acceleration**
 - Numerical Solution of differential equations using Euler’s method**
 - L’Hospital’s Rule, including its use in determining limits and convergence of improper integrals and series**
 - f) Computation of derivatives
 - Derivatives of parametric, polar and vector functions**
3. Integrals
 - a) Interpretations and properties of definite integrals
 - b) Fundamental Theorem of Calculus
 - c) Techniques of antidifferentiation
 - Antiderivatives by substitution of variables**
 - Improper integrals**
 - d) Applications of antidifferentiation

Solving logistic differential equations and using them in modeling

e) Numerical approximations to definite integrals

f) **Applications of integrals**

4. Polynomial Approximations and Series

a) **Concept of a series**

b) **Series of constants**

c) **Taylor series**

It is clear from this information that Calculus BC is more demanding than Calculus AB.

3.0 Villanova Course Equivalents

| AP Test | Test Title | Score | VU Equivalent(s) | # of Credits |
|---------|--------------------------------------------------------------------------------------------------------------------------|--------|--------------------------------------------------|--------------|
| 66 | Calculus AB | 4 or 5 | MAT 1500 Calculus I, and MAT 1505 Calculus II | 8 |
| 68 | Calculus BC | 4 or 5 | MAT 1500 Calculus I, and MAT 1505 Calculus II | 8 |
| 69 | Calculus AB subscore Test 69, a test 66 equivalency, is treated as test 66 and included in the test 66 data. | 4 or 5 | MAT 1500 Calculus I, and MAT 1505 Calculus II | 8 |

Table 1. Rules for the offer of academic credit for calculus courses.

The purpose of the Villanova study was to provide students, parents, and faculty with a performance record of students who scored well enough on AP calculus tests to be offered Villanova credit. This work examined and demonstrated how previous students, who were been offered AP calculus credit, performed in the first math course taken at Villanova. The first author tracked the performance of incoming freshmen, over three successive years, who chose either to accept or not to accept offered AP calculus credit.

Academic credit is offered to the incoming freshman students based on information in Table 1. Students who are offered Villanova course credit for both Calculus I and Calculus II may elect to take credit for both, one, or none of the offered equivalents.

At Villanova there are five engineering programs: Chemical, Civil and Environmental, Computer, Electrical, and Mechanical. All programs require MAT 1500 Calculus I, MAT 1505 Calculus II, and MAT 2705 Differential Equations with Linear Algebra. Only the Civil Engineering program and the Mechanical Engineering program require MAT 2500 Calculus III which, among other topics, covers multi-variable calculus.

During the three years of the study, students who accepted the offered AP credit for Calculus I and Calculus II were registered for Differential Equations in their freshman fall semester.

Students who accepted offered-credit for only Calculus I were directed to Calculus II; and students who accepted no offered-Calculus credit took Calculus I.

The data collected were the grades achieved in the students' first math course at Villanova, whether it was Differential Equations, Calculus II, or Calculus I. The following data are presented in a form that attempts to show the relationship between AP test title and score achieved, and the grade achieved in the first math course taken at Villanova.

Grade distribution was measured by:

- a. Grades of B and above,
- b. Grades of B- through C,
- c. Grades of C- or below.

The Data and Findings

1.0 Comparisons by Test Title, Score, Credit Acceptance Choice

The following comparisons demonstrate relative first-math-course achievement. So that students and parents could easily identify and view information for the specific AP test taken and score received, the data in the first four comparisons are presented by the four test title and score possibilities:

- a. Calculus AB, score of 4,
- b. Calculus AB, score of 5,
- c. Calculus BC, score of 4,
- d. Calculus BC, score of 5,

followed by the three credit acceptance choices:

- a. accepted AP credit for both Calculus I and Calculus II,
- b. accepted AP credit for Calculus I only,
- c. accepted no AP calculus credit.

1.1 Calculus AB, Test 66, Score of 4

Thirty-six students accepted credit for Calculus I and Calculus II. All students took Differential Equations in the fall semester with two exceptions: two students took Calculus III and received grades of B- and B. Thirteen students accepted credit for Calculus I only. All the students took Calculus II in the fall semester. Twenty-one students declined all Calculus credit and took Calculus I in the fall semester. These results are presented in Fig. 1.

Calculus AB, Score of 4

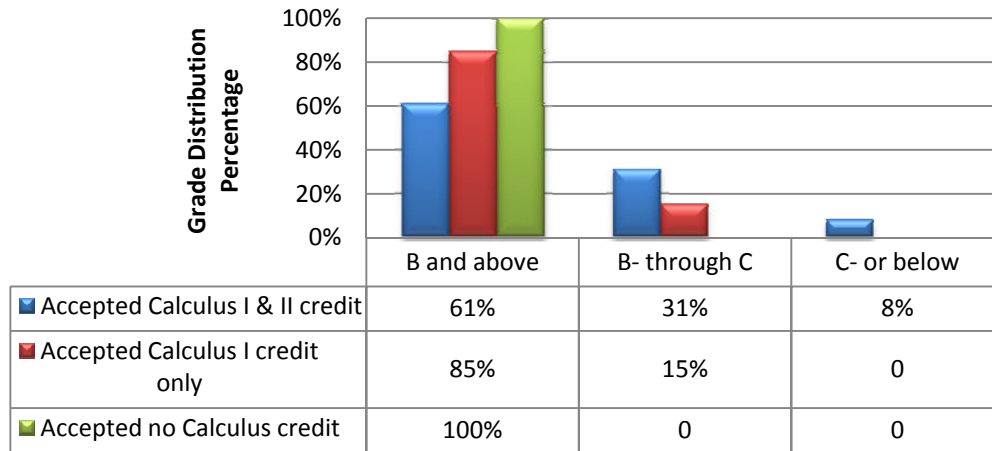


Figure 1: Performance of students who scored 4 in Calculus AB, test 66. The first row of text corresponds to the first column of the plot, the second row to the second column, and the third row to the third column.

1.2 Calculus AB, Test 66, Score of 5

Sixty-seven students accepted credit for Calculus I and Calculus II. All students took Differential Equations in the fall semester with one exception: a student who took Calculus III and received a grade of A. Another student, who took Differential Equations and Calculus III for which he received grades of A and A-, respectively, is counted as two individuals. Eighteen students accepted credit for Calculus I only. All the students took Calculus II in the fall semester. Nine students declined all Calculus credit and took Calculus I in the fall semester. Results from this section appear in Fig. 2.

Calculus AB, Score of 5

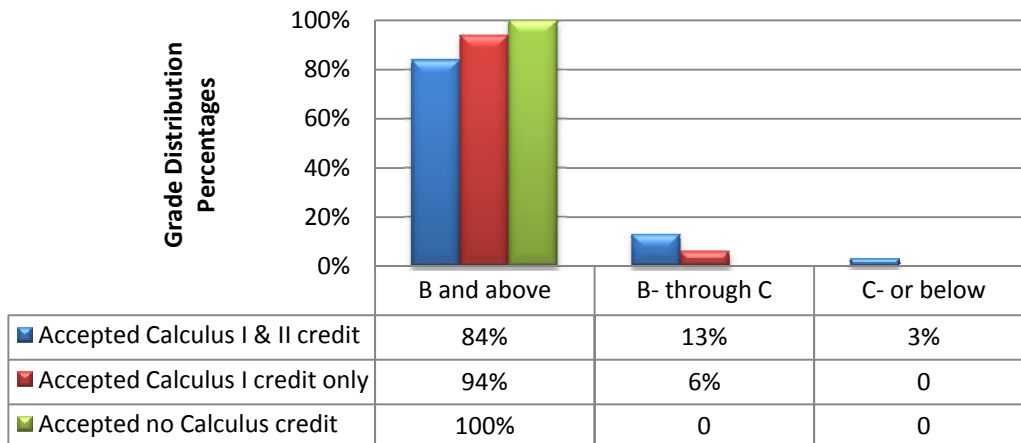


Figure 2: Performance of students who scored 5 in Calculus AB, test 66.

1.3 Calculus BC, Test 68, Score of 4

Seven students accepted credit for Calculus I and Calculus II. All students took Differential Equations in the fall semester. Seven students accepted credit for Calculus I only. All the students took Calculus II in the fall semester. Two students declined all Calculus credit and took Calculus I in the fall semester. Results from this section are presented in Fig. 3.

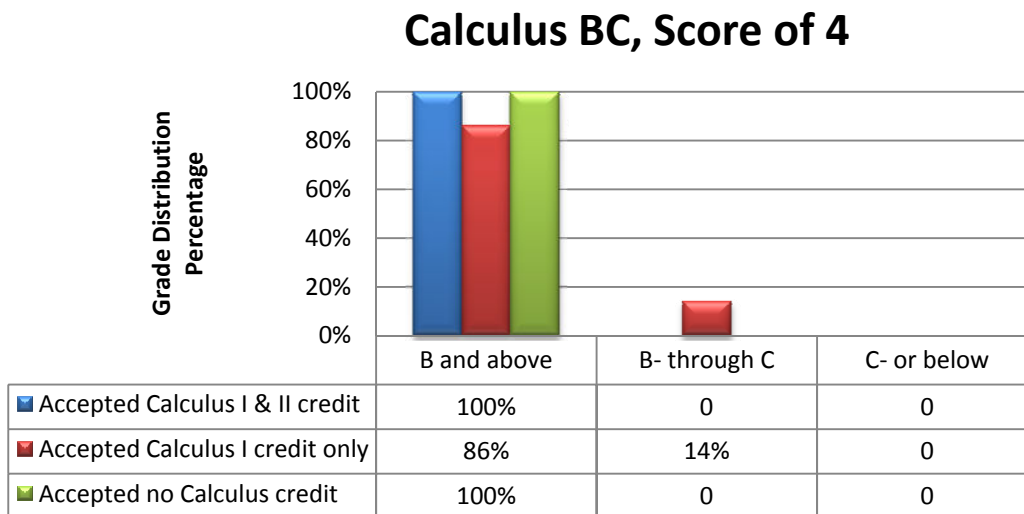


Figure 3: Performance of students who scored 4 in Calculus BC, test 68.

1.4 Calculus BC, Test 68, Score of 5

Twenty-nine students accepted credit for Calculus I and Calculus II. All students took Differential Equations in the fall semester. Six students accepted credit for Calculus I only. All the students took Calculus II in the fall semester. Two students declined all Calculus credit and took Calculus I in the fall semester. Results from this section appear in Fig. 4.

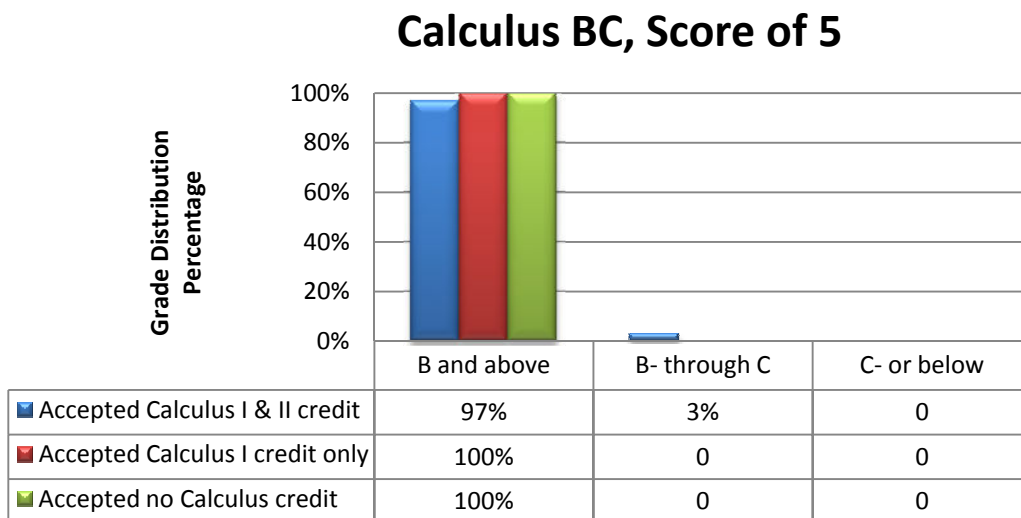


Figure 4: Performance of Students who scored 5 in Calculus BC, test 68.

2.0 Comparisons by Credit Acceptance Choice, Test Title, Score

To compare students' performance by their acceptance choices, data are presented by the three credit acceptance choices:

- a. accepted AP credit for both Calculus I and Calculus II,
- b. accepted AP credit for Calculus I only,
- c. accepted no AP calculus credit,

followed by the four test title and score possibilities:

- a. Calculus BC, score of 5,
- b. Calculus BC, score of 4,
- c. Calculus AB, score of 5,
- d. Calculus AB, score of 4.

Results for the above appear in Figs. 5-7.

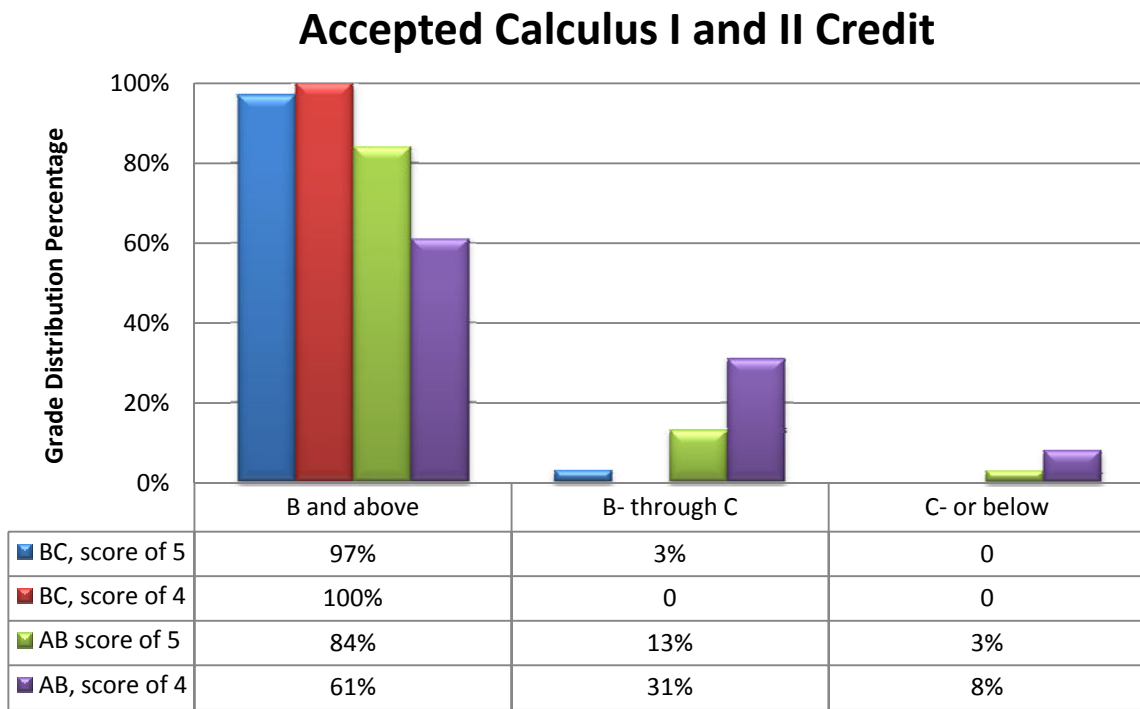


Figure 5: Performance of students who accepted Calculus I and II credit. The first row of text corresponds to the first column of the plot, the second row to the second column, the third row to the third column, and the fourth row to the fourth column.

Accepted Calculus I Credit only

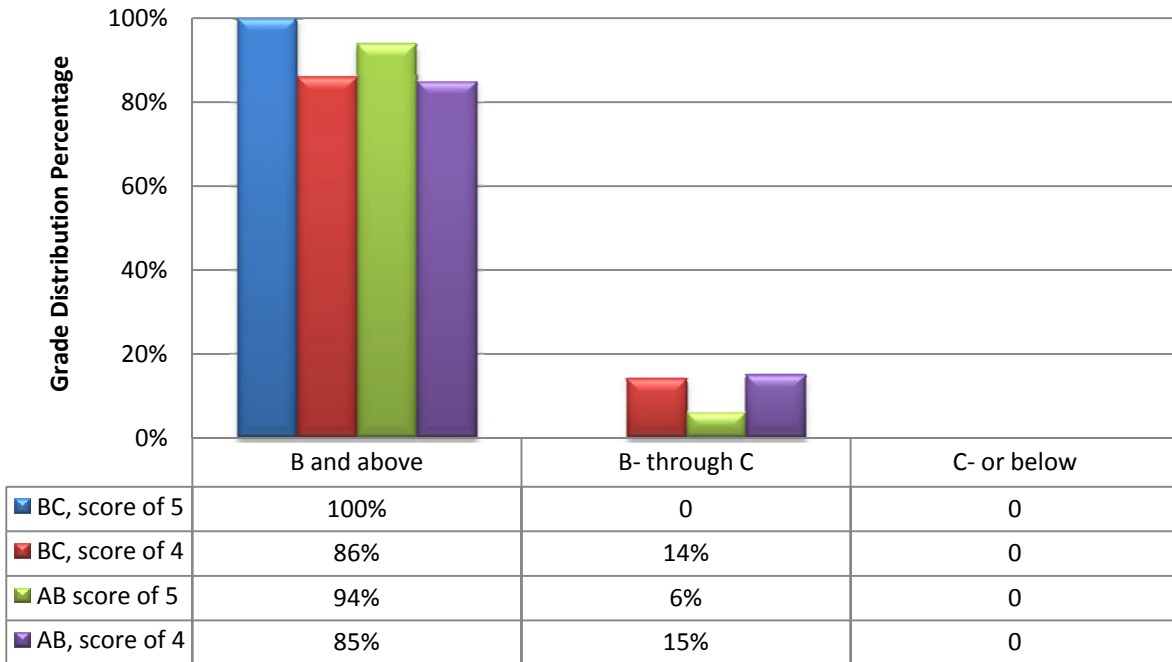


Figure 6: Performance of students who accepted Calculus I credit only.

Accepted No Calculus Credit

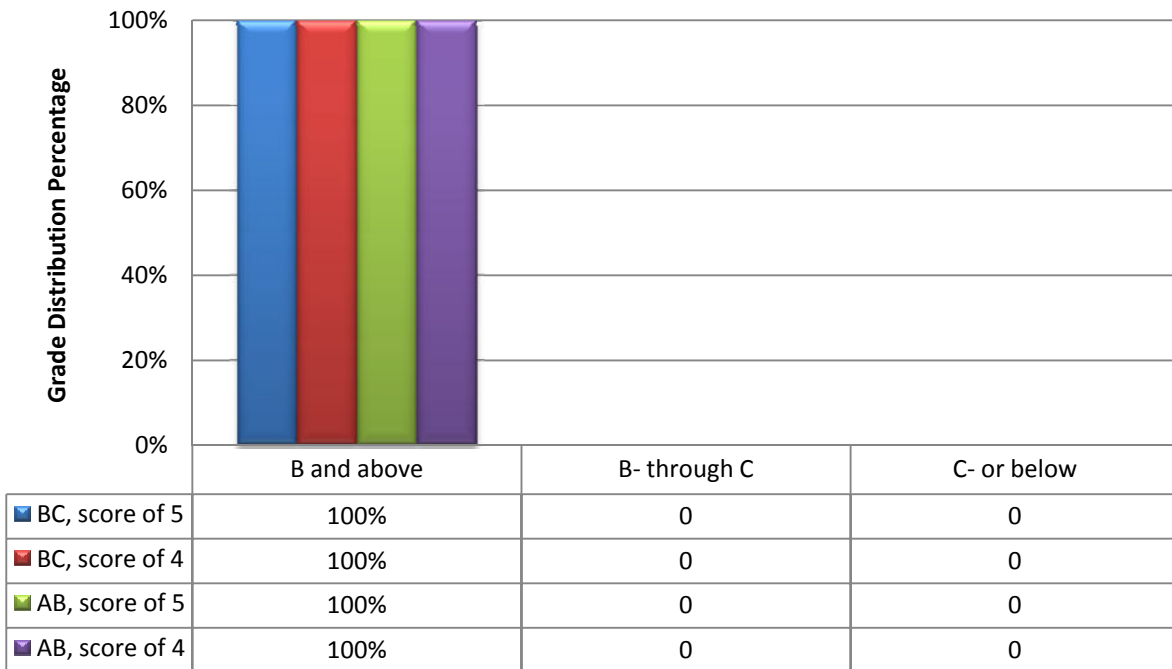


Figure 7: Performance of students who accepted no Calculus credit.

Discussion and Conclusions

The key findings from this study are as follows:

1. A relationship between AP achievement and grades earned in math courses taken in the fall semester of freshman year is observed. Students who took test BC achieved better grades than students who took test AB. This is to be expected because test BC is more demanding than test AB.
2. Students who took test BC had very good grades whether or not they accepted credit. Of the 53 students who took test BC, all but two (3.7%) achieved grades of B or better in their first math course.
3. Of the students who took test AB, those who opted for credit for Calculus I, but not for Calculus II, achieved better grades than comparable students who accepted credit for Calculus I and Calculus II. The students' decisions in this case were perhaps based on self-awareness and their realization that they may have been offered credit for a course (Calculus II) for which they felt inadequately prepared. Students who opted for no calculus credit achieved better grades in Calculus I than comparable students achieved in Calculus II who accepted credit for Calculus I.
4. All students with high school AP Calculus course experience, who declined the offered college credit, performed well in their Calculus I course, achieving grades of B or better.
5. In summary, we can state that the more challenging the AP test, and the higher the grade achieved, the more the mastery of the topics. This trend is seen most clearly in Figs. 5, 6, and 7 where, in most cases, the fraction of students receiving grades lower than B decreases with increases in both test level and score.

The information contained in this paper was not made available, i.e., not posted on our website, to the students who participated in this study. Thus, no student choices were affected by the recommendations made here.

In addition to the present work, an attempt was made to correlate student performance in the first technical (i.e., non-math) course in the students' majors with their acceptance or non-acceptance of AP Calculus credit. The results of this investigation were inconclusive because of the smallness of the sample sizes in each major and grading variability among the technical courses in the five majors.

The purpose of the Villanova study, to provide students and parents with practical information about AP calculus choices by demonstrating a record of past performance of students who have chosen or not chosen to accept offered AP calculus credit, does not account for the many different factors that can determine a student's success in a course. Nor has enough data been collected to indicate a clear trend that is statistically significant. Data collection continues, however. In no way should the data and results in this paper be construed as a guarantee of future success in courses for students who do choose to use their AP credit.

While this three-year sampling is small, it could be used to offer practical advice to incoming students and their parents who are trying to make a decision about accepting all, part, or none of the offered AP calculus credit.

As a result of this study, incoming students who took test 66 and received a score of 5 (and certainly a score of 4) and their parents are now more strongly encouraged to seriously consider whether to accept AP Calculus credit, with the goal of incoming students' having full comprehension of calculus material before continuing in their engineering programs. This is consistent with the Purdue study⁵ noted above.

References

1. Glenn, David, "Scholars Say College Admissions Offices Misuse Advanced Placement Data," *Chronicle of Higher Education*, Jan. 21, 2005.
2. Mathews, Jay, "Phantom AP Study Lurks," www.washingtonpost.com, Nov. 28, 2006.
3. Pieronek, C., "Advanced Placement Credit: A Double-Edged Sword in Engineering Education," *2007 American Society for Engineering Education*.
4. Bressoud, David M., "AP Calculus: What We Know," *2009 The Mathematics Association of America*.
5. Budny, D.D., Bjedov, G and LeBold, W, "Assessment Of The Impact Of The Freshman Engineering Courses", *Proceedings 1997 ASEE-IEEE Frontiers in Education Conference, Nov. 5 - 8, 1997, Pittsburgh, PA*.
6. Anon., "Calculus AB Calculus BC Course Description," *May 2006, May 2007 College Board AP*.